The Science of Diversity
and its Relevance in a Fast Changing World

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Diversity - As the morally right thing to do

- My view, for a long time, was that supporting diversity was is morally the right thing to do …
  - And I naively assumed it was the same as affirmative action.
  - I had a fundamental conflict: Diversity was said to be a good thing, but introducing diversity seemed to introduce conflict
- Where did that come from?
  - I think it's because the idea of natural selection - popularized as "survival of the fittest" – dominates our view of the world.

I was asked to “Make it Personal”

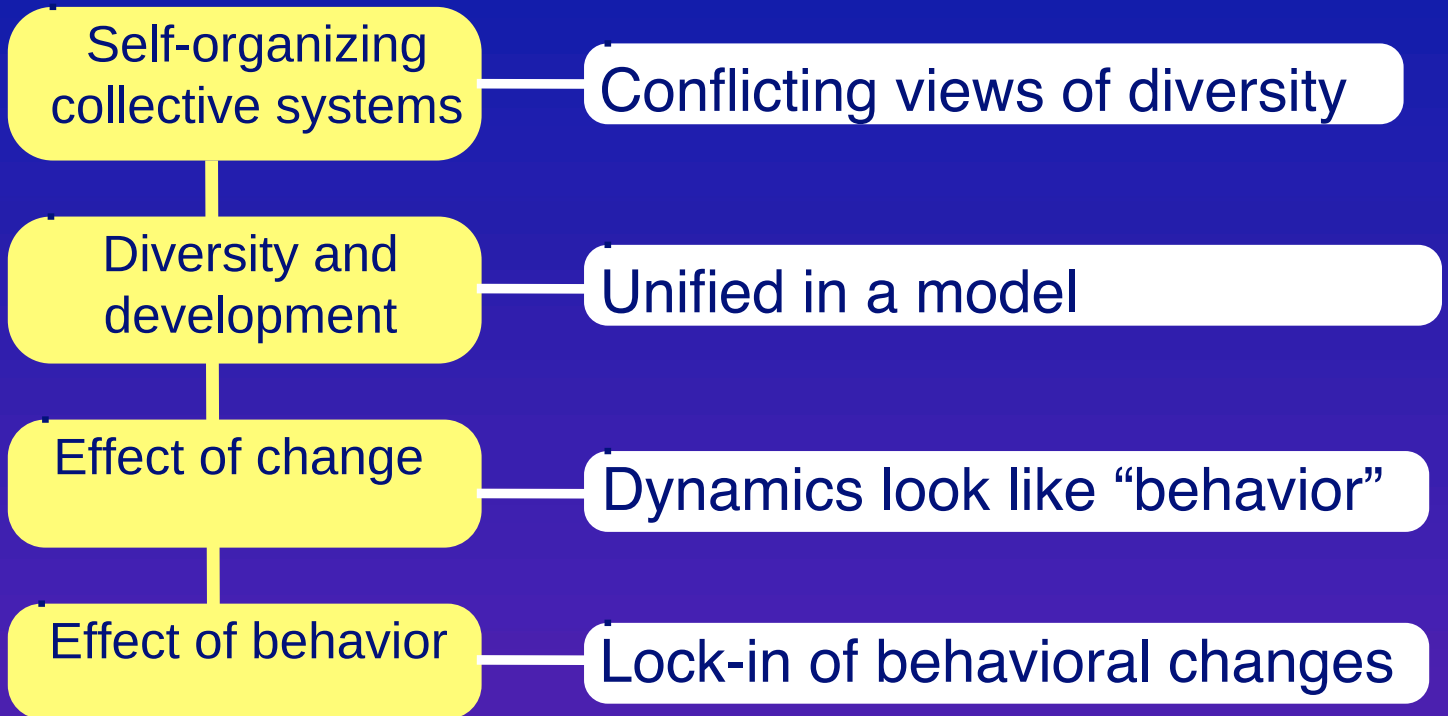
- **Why am I here today?**
- **What made me become an advocate for Diversity? Especially since I’m:**

White - Northern European
Male
Q- Cleared
Ph.D.
US born
Exit-seating capable

The Trouble with Techies

- ***Training technical staff (from Lionel LaRoche):***
  - Technical people may not be receptive to games and playful activities
  - They will tend to analyze training activities looking for how they work and the reasons they are designed as they are.
  - They may run the activity in their heads (i.e., as a thought experiment) rather than doing it physically as intended by the trainer.
  - Qualitative data will have little probative value to them.
  - They will want to fully understand how quantitative data was collected and conclusions drawn from it.
  - Technical people may not be as versed in "human processes and group dynamics" and so may have more trouble completing tasks relying on those skills

Roadmap to a collective model



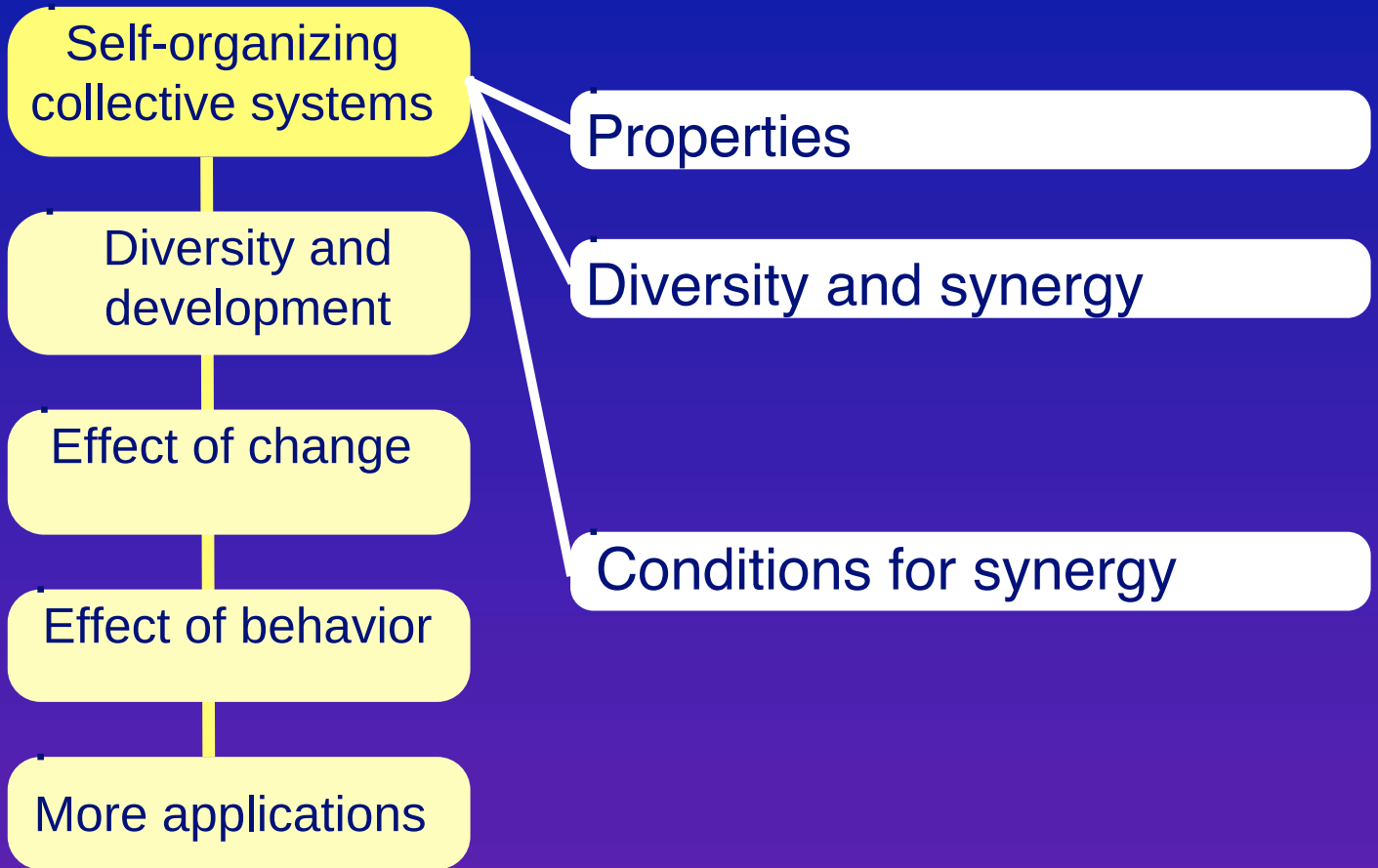
Y2K was?

- 1. One of the greatest wastes of money/ energy of all times.
-
- 2. Taken seriously, and prevented.
-

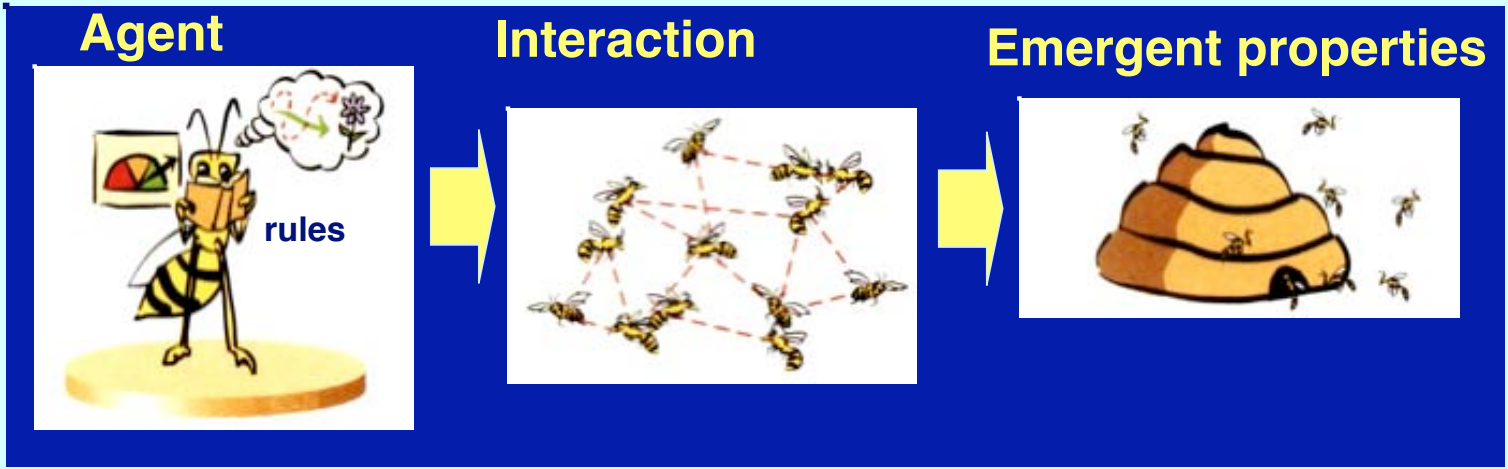
How well do we understand?

- **The Real Significance of Y2K**
- **To what degree can “society” fail and society still continue?**
- This is a major admission of the ignorance about our understanding of how decentralized systems really work and survive.

Roadmap

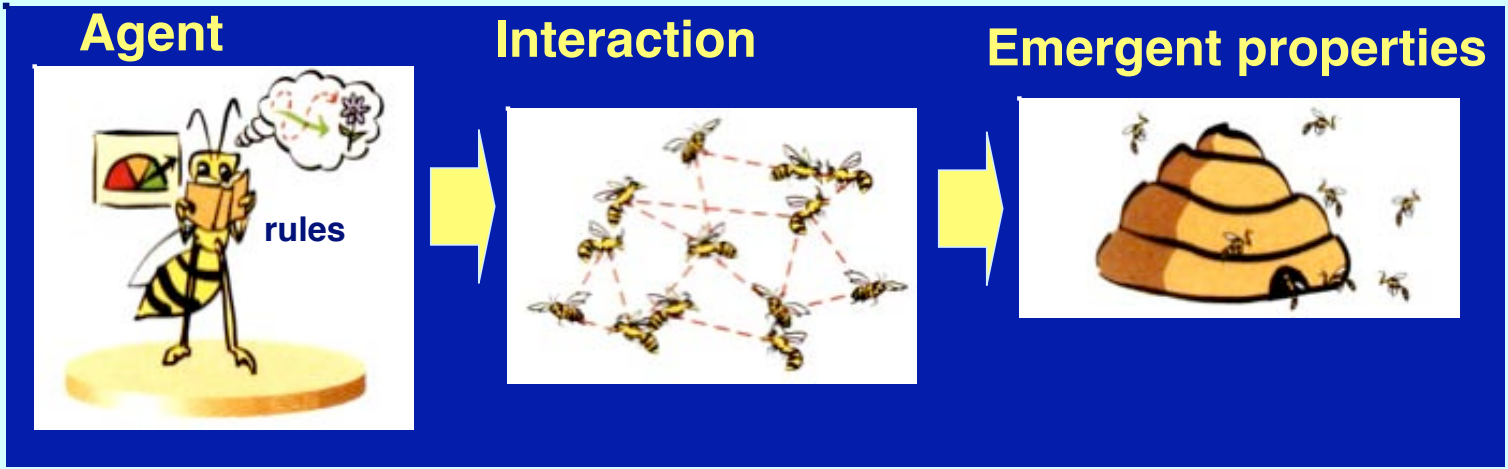

Self-organizing collective systems
Diversity and development
Effect of change
Effect of behavior
More applications
Properties
Diversity and synergy
Conditions for synergy

Self-Organizing Collective Systems



A subset of complex adaptive systems

Self-Organizing Collective Systems



"Solutions" arise from the dynamics from a diversity of potential solutions.
Decentralized, robust, adaptable, fault-tolerant, scalable, ...

Fundamental concepts

Emergent properties

Chaotic behavior *or* non-linear response

Structure in chaos

Defining Emergent Property

Popular and scientific definition:

- A global property of a system that is surprising and unexpected
-

A better working definition:

- A global property that cannot be predicted from knowledge of the subcomponents (agents)

Examples of Emergent Properties

Physical systems: viscosity is a property of a collection of atoms

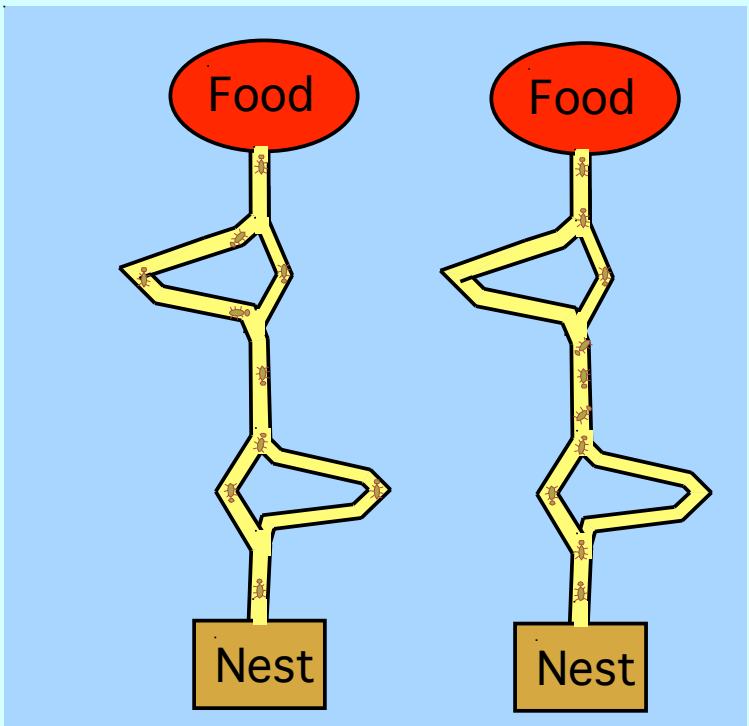
The Stock Market: no expert consistently beat the market as a whole (even including the "bad" investors)

Social insects

All of these present significant challenges to an "Expert" trying to describe how these work and to predict their future.

Ants Solving “HARD” problems

Most ants foraging for food find the shortest path.

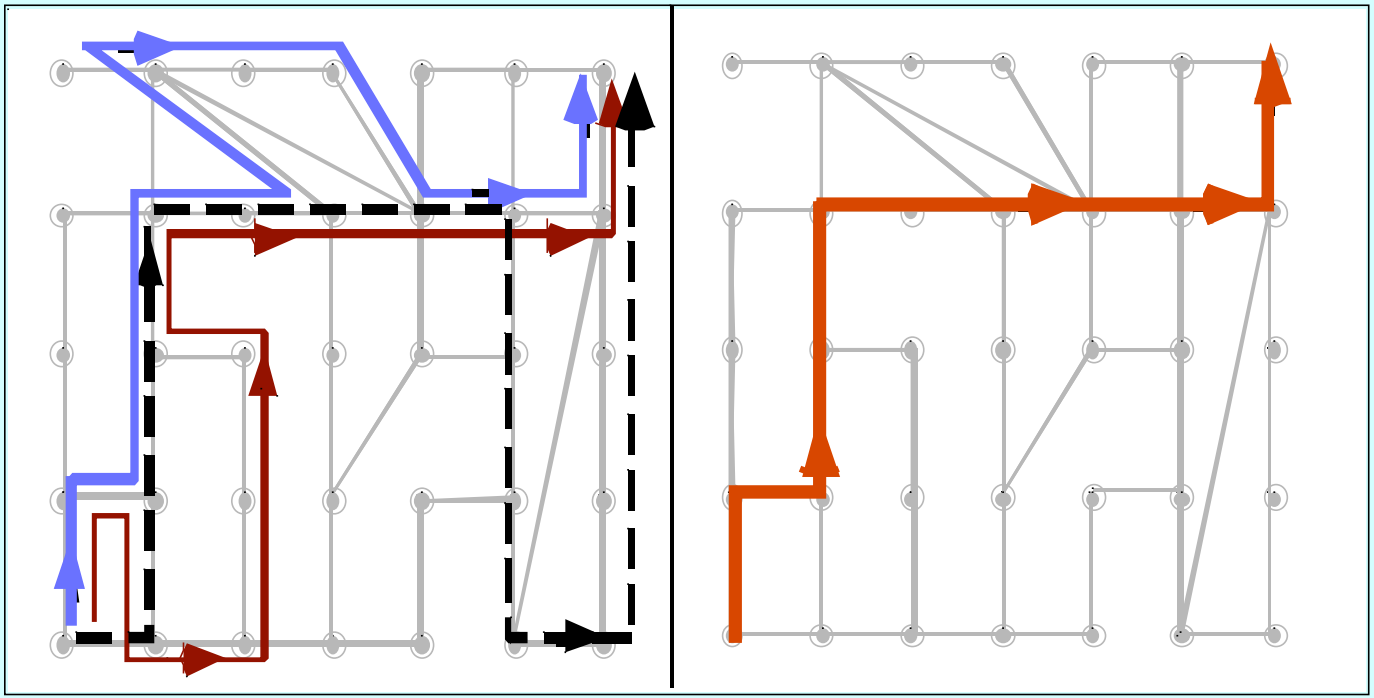


How is this possible?

- **No global perspective**
- **Individual behavior is “dumb” & chaotic.**
- **No leaders or central coordination**

How does it work?

How ants find the Shortest path



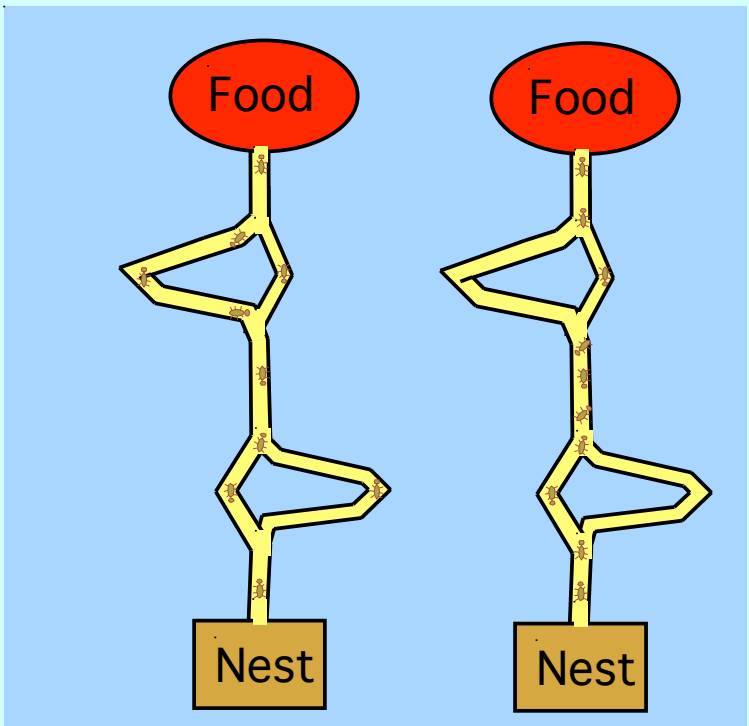
Paths of three ants

Collective path

Diverse pheromone trails (with or without evaporation)

Ants Solving “HARD” problems

Most ants foraging for food find the shortest path.



How does it work?

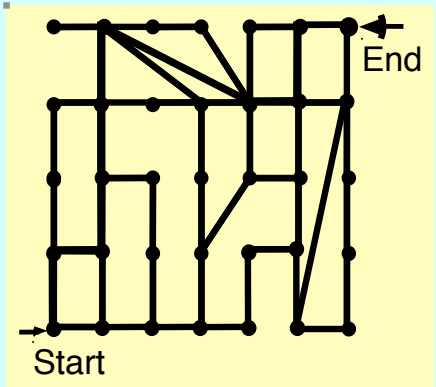
Only works for groups of diverse ants

Easy to show: suppose all the ants take the identical path. Then the collective cannot find the shortest path!

Research on Collective Self-Organization

The global emergent property is insensitive to details of the model, except:

- Groups of individuals with random searches show no collective advantage Hence, individual and collective performance are coupled.



Performance and robustness are highly correlated with Diversity

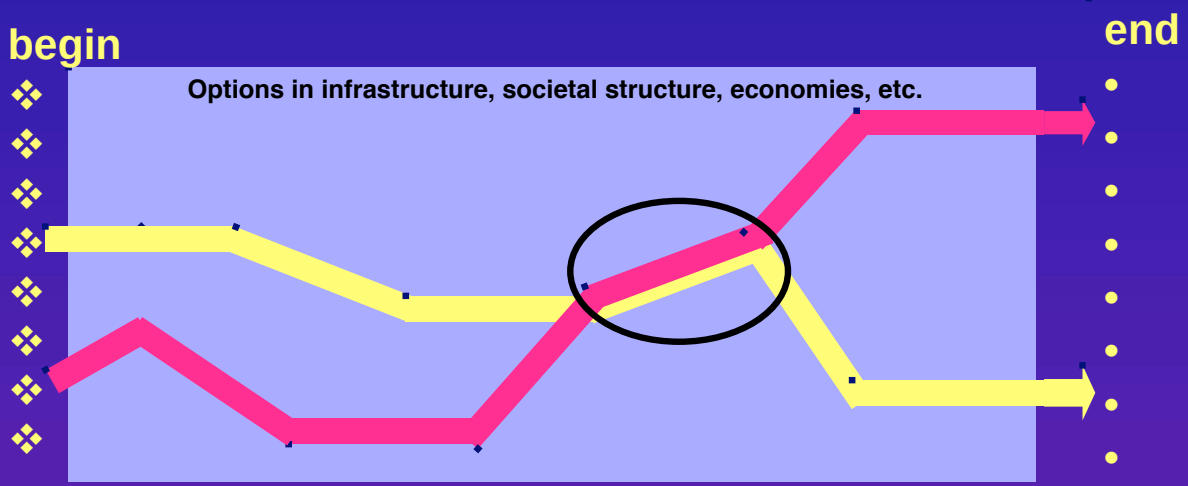
Diversity leads to better global solutions
Diversity leads to insensitivity to noise
Selection lower global performance

Sharing information speeds convergence to the optimal path, but at the price of diversity and robustness

Collectives in complex environments

In complex domains:

- Beginning points differ
- End points differ
- But partial paths can overlay and find synergy



Diversity - source of conflict or synergy?

Diversity leads to synergy when collectives have:

- Common goals
- Common worldview (agreement on options), but with different preferences or goals
- Common identity

Otherwise, diversity can lead to competition and conflict

One Business Argument

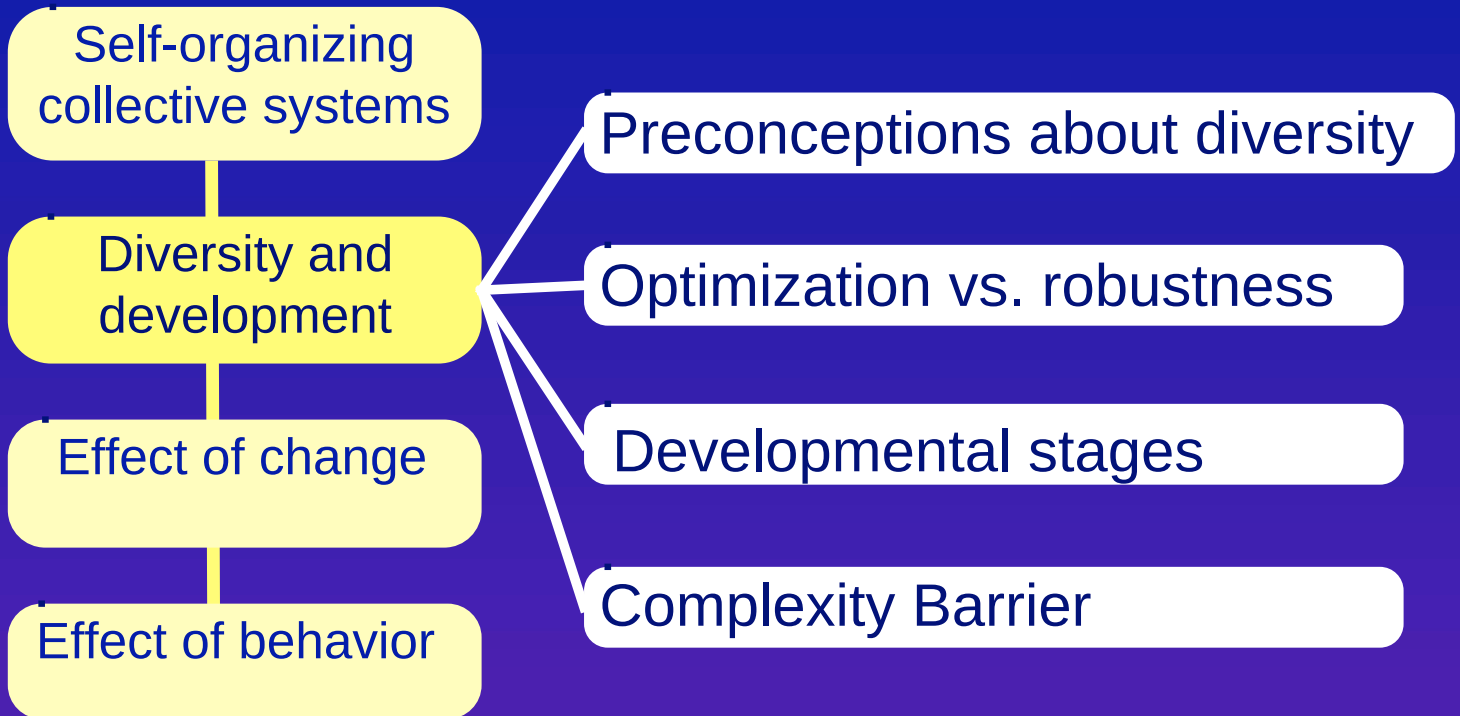
70% of our work knowledge is from informal sources
Two year, $1.6 million DOL study of Motorola, Boeing, Ford, etc.

$100-120 billion a year is spent on formal training programs,
Yet in complex situations, how is the "best training" determined?

Why are these informal sources helpful?
Individual problem solving in a common environment.
Diversity gives unique perspectives.
Individuals contribute to something much greater than they perceive.

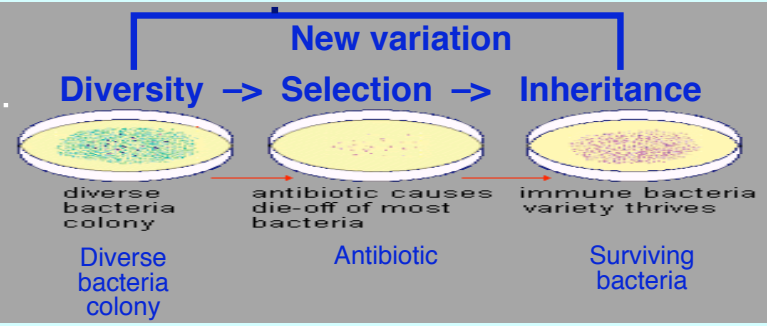
How do we tap the huge collective resources?
Investment in enabling Diversity activates informal learning.
Individuals expression, Listen to others, Mixing communities.

Roadmap


Self-organizing collective systems
Diversity and development
Effect of change
Effect of behavior
Preconceptions about diversity
Optimization vs. robustness
Developmental stages
Complexity Barrier

Diversity and Natural Selection

Engine of Natural Selection



Higher performance results as a consequence of selection from a diverse population.

Diversity lowers the global performance:

Lower performance of "unfit" individuals leads to lower "average" population performance

Two Processes Using Diversity

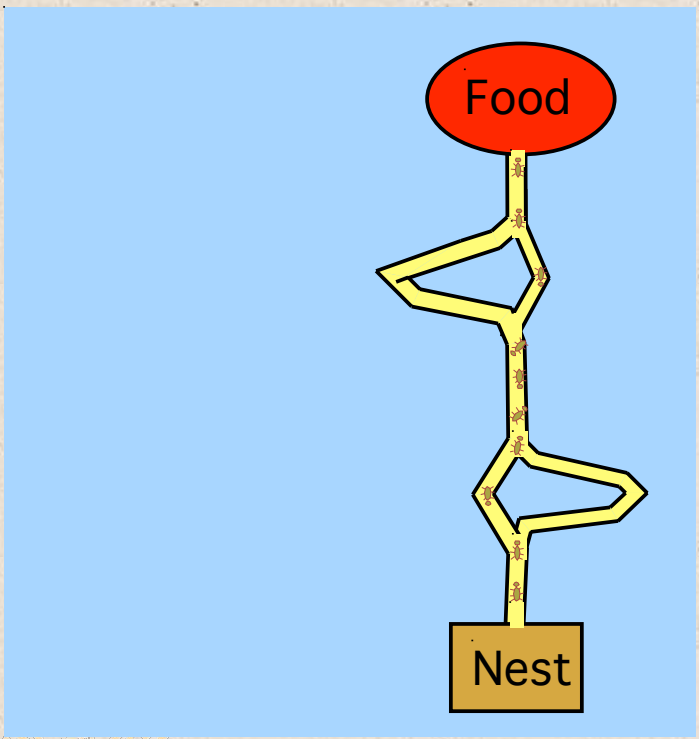
Forming definition

Selection gives
Agents capability.

Improvement by collective

Synergy of Diverse
individual contributions

An “Optimized” collective solution shows little diversity



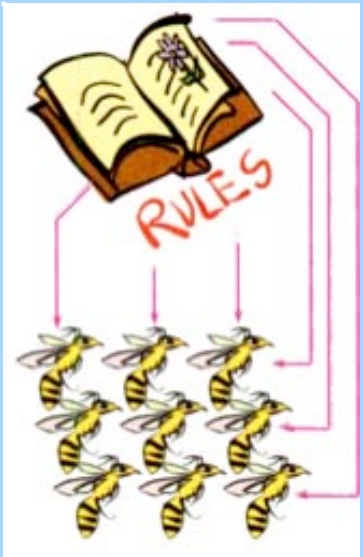
Social insects planned for this…

Three Mechanisms for Performance

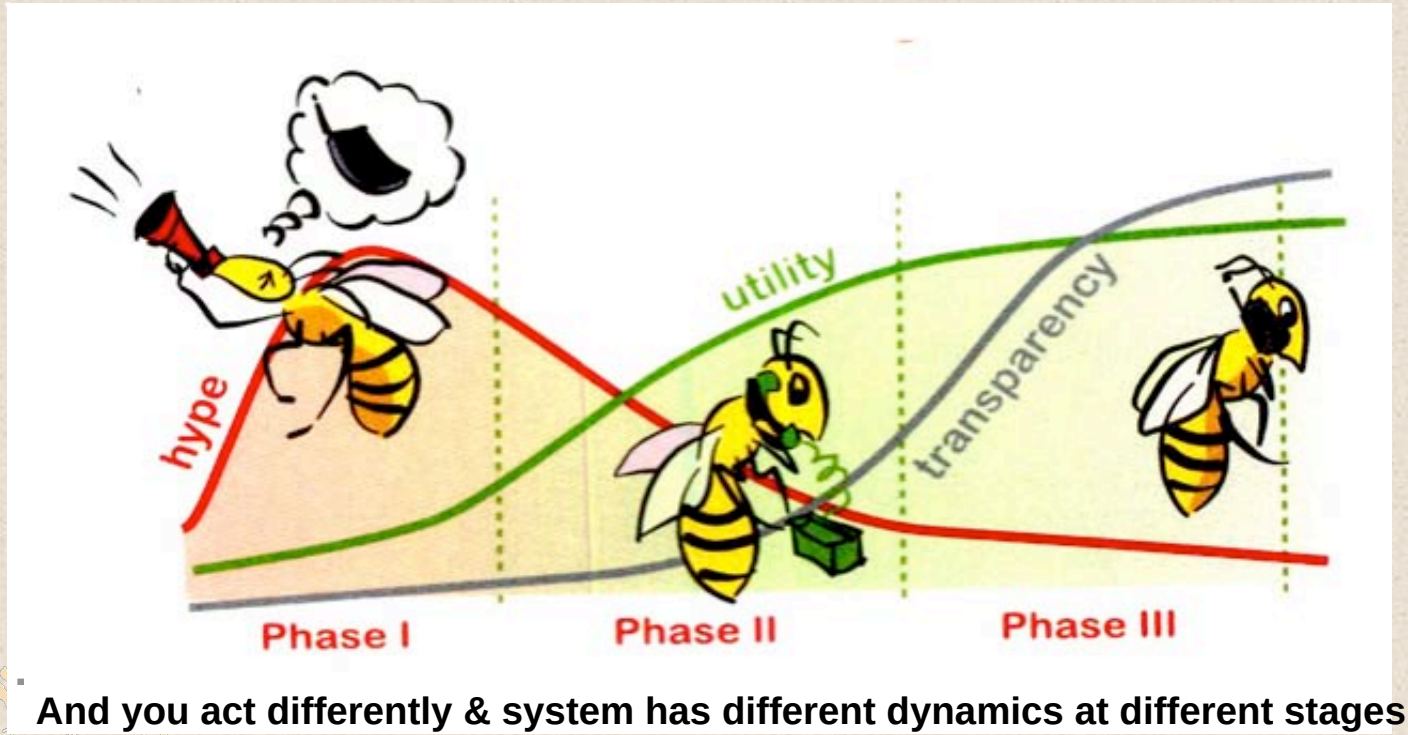
Selection

Synergy

Optimization

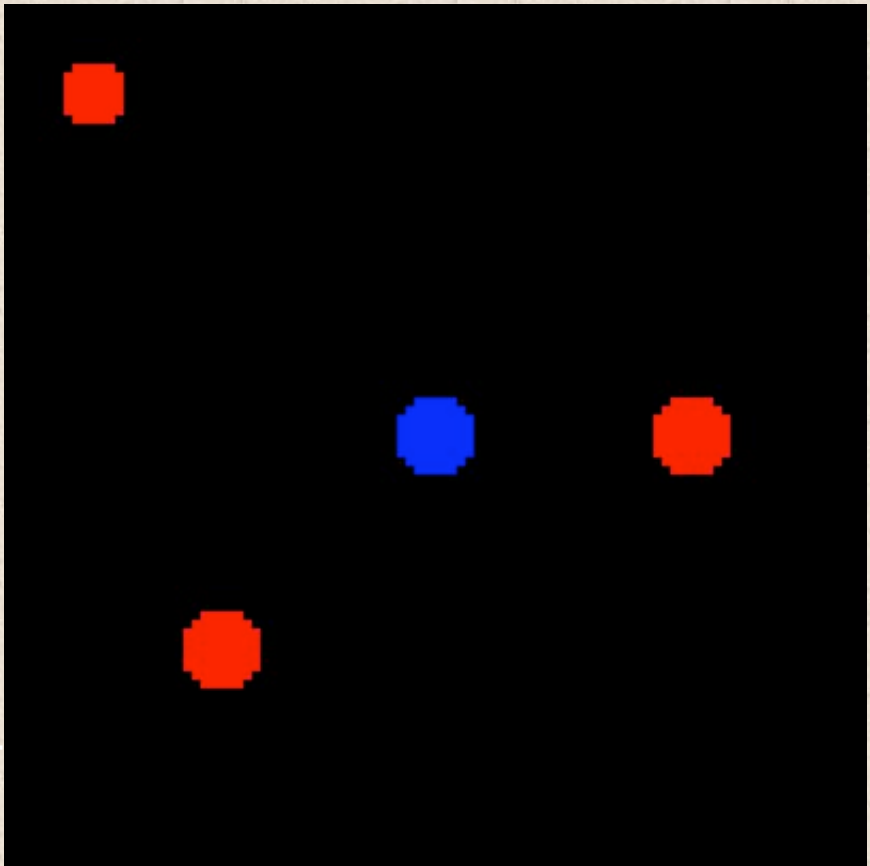


Developmental Stages of Consumer Technology



And you act differently & system has different dynamics at different stages

Simple Ant Consumer Model



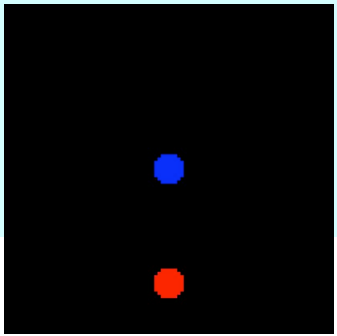
Collective information
- Evaporation
- Diffusion

Agent internal state:
- Current direction
- Have food?

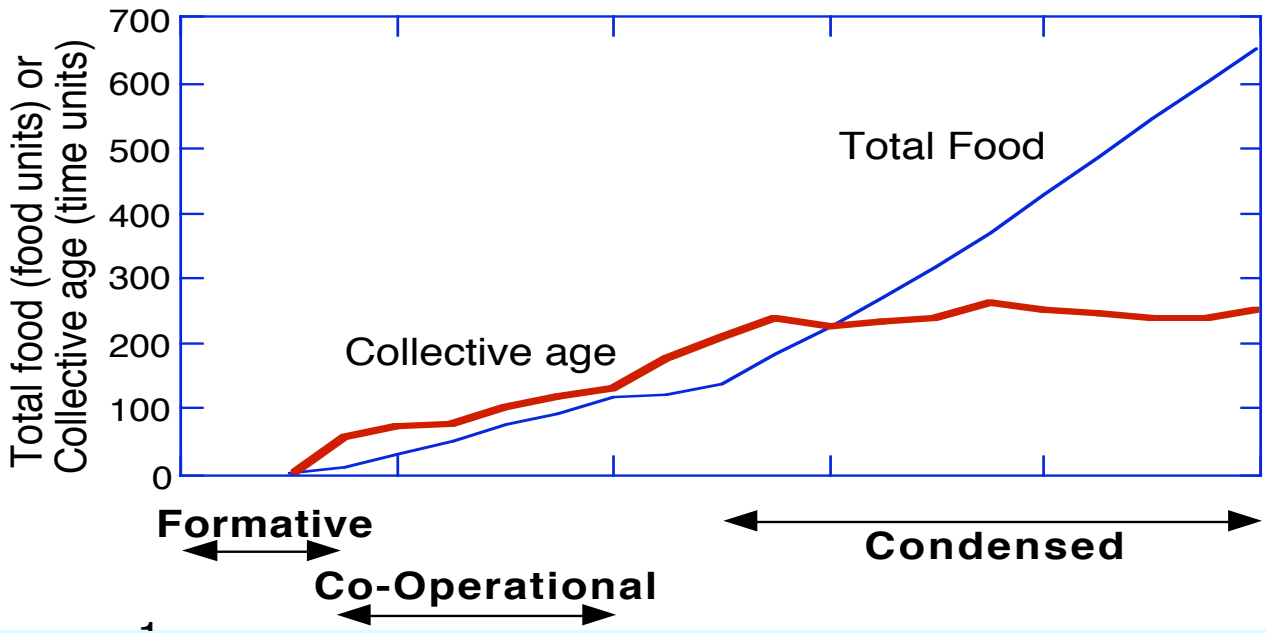
Three rules of action:
- Carry food
- Drop food
- Search

Productive collective
"Salaried men"
Individual/Innovator
Collective structure

Three stages for a stable environment



Total Production versus time

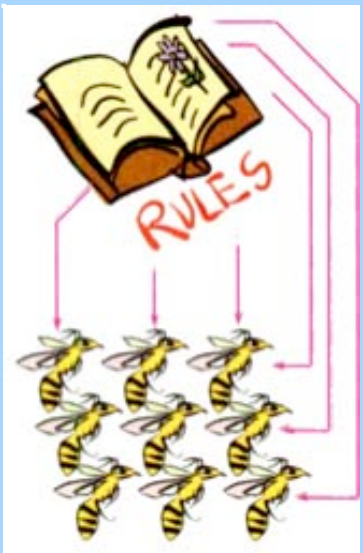


Stages of Collective Development

Formative
Forming definition

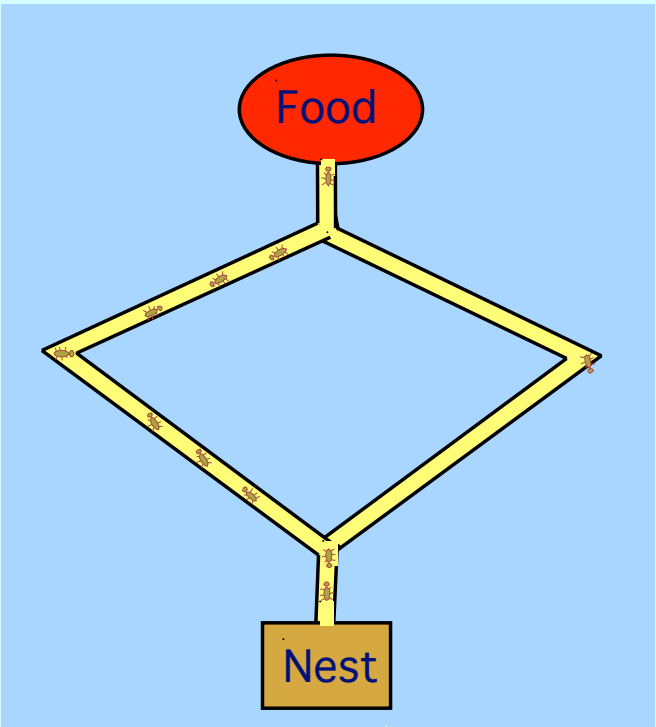
Co-Operational
Improvement by collective

Condensed
System optimization



The Problem with a Condensed Collective

- Ants foraging for food chose one path out of two equidistant paths.



(Deneubourg et al. 1990)

Cooperation leads to low diversity in stable environments

Non-linear or Chaotic behavior: Positive reinforcement can amplify random weak signals >> global chaos

Stages of Development

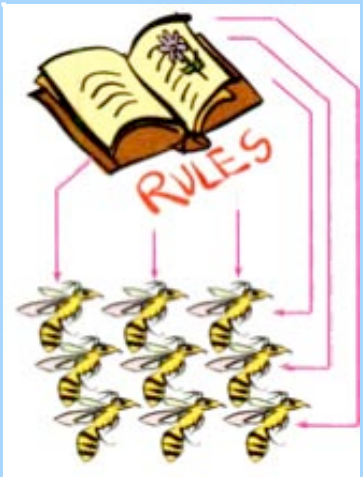
Formative

- Locally chaotic (agent's path)
- Globally chaotic (productivity)
- Robust global performance
- Production by "innovative" agents
- **High diversity**

Co-Operational

- Locally chaotic
- Globally predictable
- Robust global performance
- Production by both classes
- **High diversity**

Condensed



- Locally predictable
- Globally predictable
- Fragile
- Production by collective
- **Low diversity**

What is an Expert in your Area?

- *1. Someone that tells you the rules to make good decisions.*
- *2. Someone that gives you good decisions, but the rules claimed for his decisions aren't useful.*

What is an Expert?

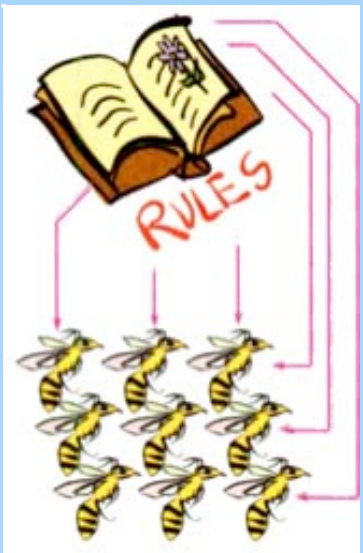
- *Someone that tells you rules or decisions?*
- *"Expert" systems only work if the expert cognitively understands the system.*
- *Otherwise, "Co-Operational" approaches are the best way to predict the future.*

Why not optimize directly?

Formative
Forming definition

Co-Operational
Improvement by collective

Condensed
System optimization



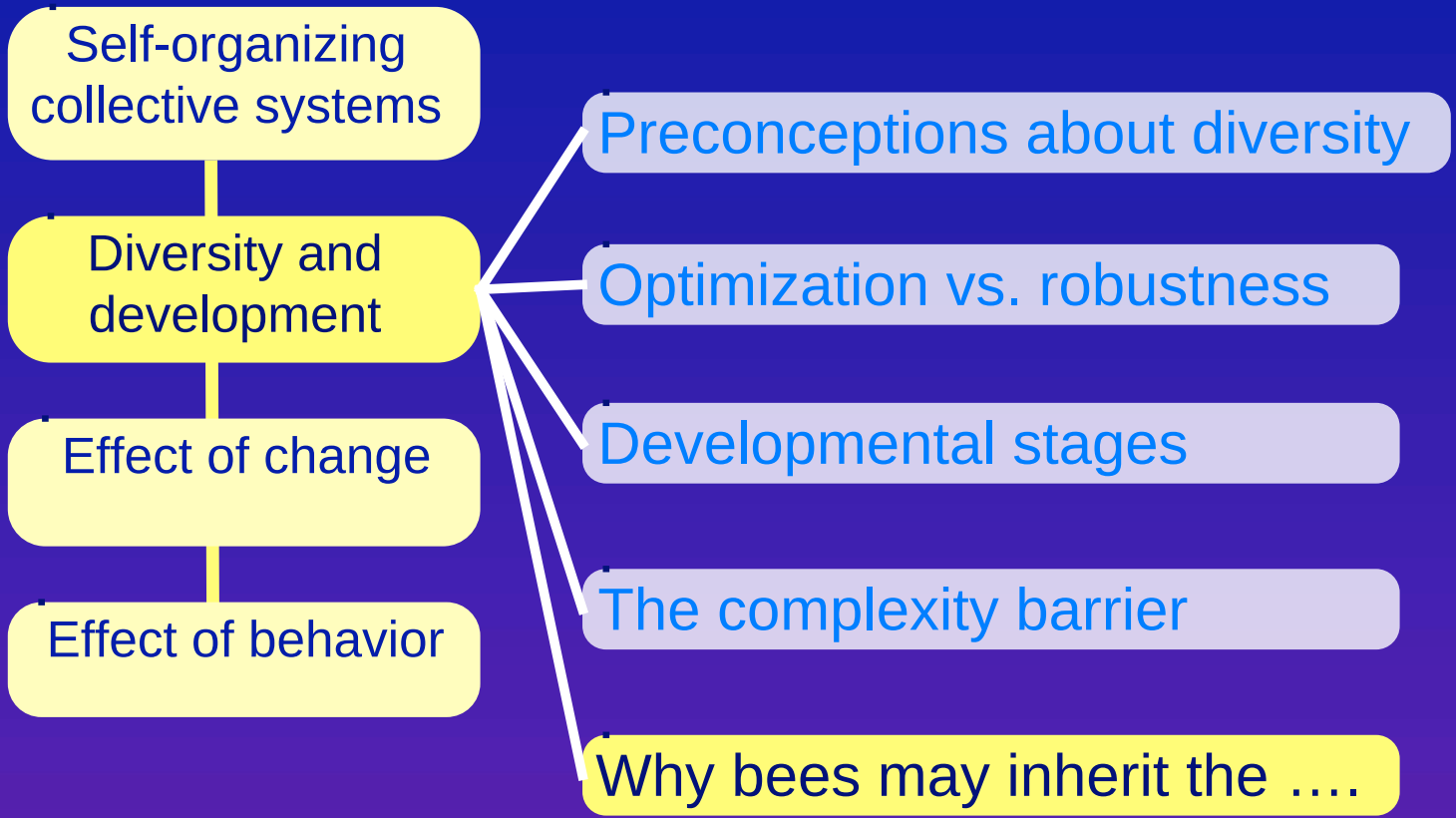
X

Complexity Barrier

Examples of the Complexity Barrier

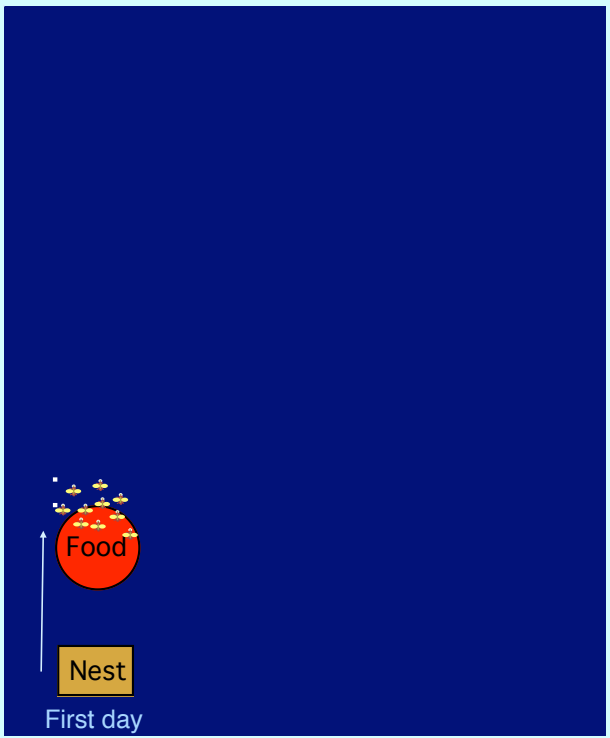
- **When many genotypes lead to one phenotype, traits become independent of selection** (*Shipman*)
- **When complexity of the global problem increases, selection in genetic algorithms do not result in improvement** (*Hart*)
-

Roadmap

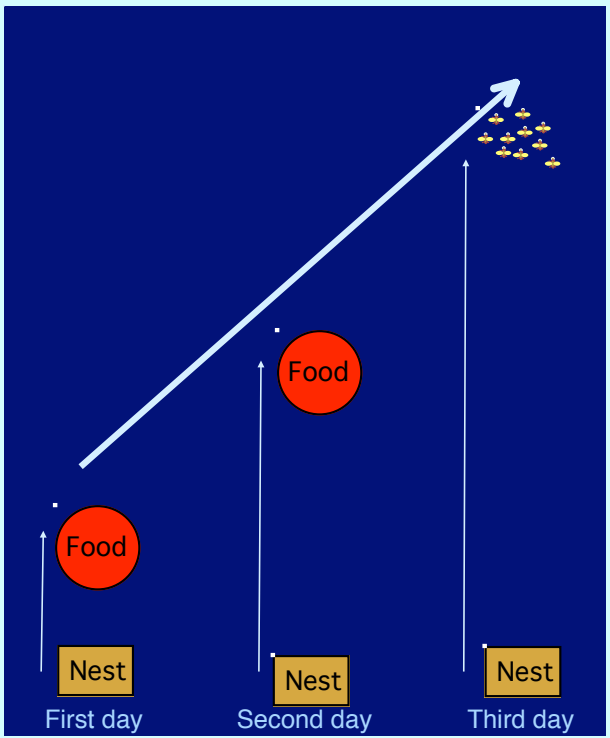

Self-organizing collective systems
Diversity and development
Effect of change
Effect of behavior
Preconceptions about diversity
Optimization vs. robustness
Developmental stages
The complexity barrier
Why bees may inherit the ….

Researching Bee Talk

Don’t underestimate collectives



Researching Bee Talk



Where is the prediction taking place?

Where is memory located?

Bee memory - 1 week
Bee life - 6 week.
Hive memory - 12 weeks.

Why are social insects so disturbing?

All hive functions are emergent properties

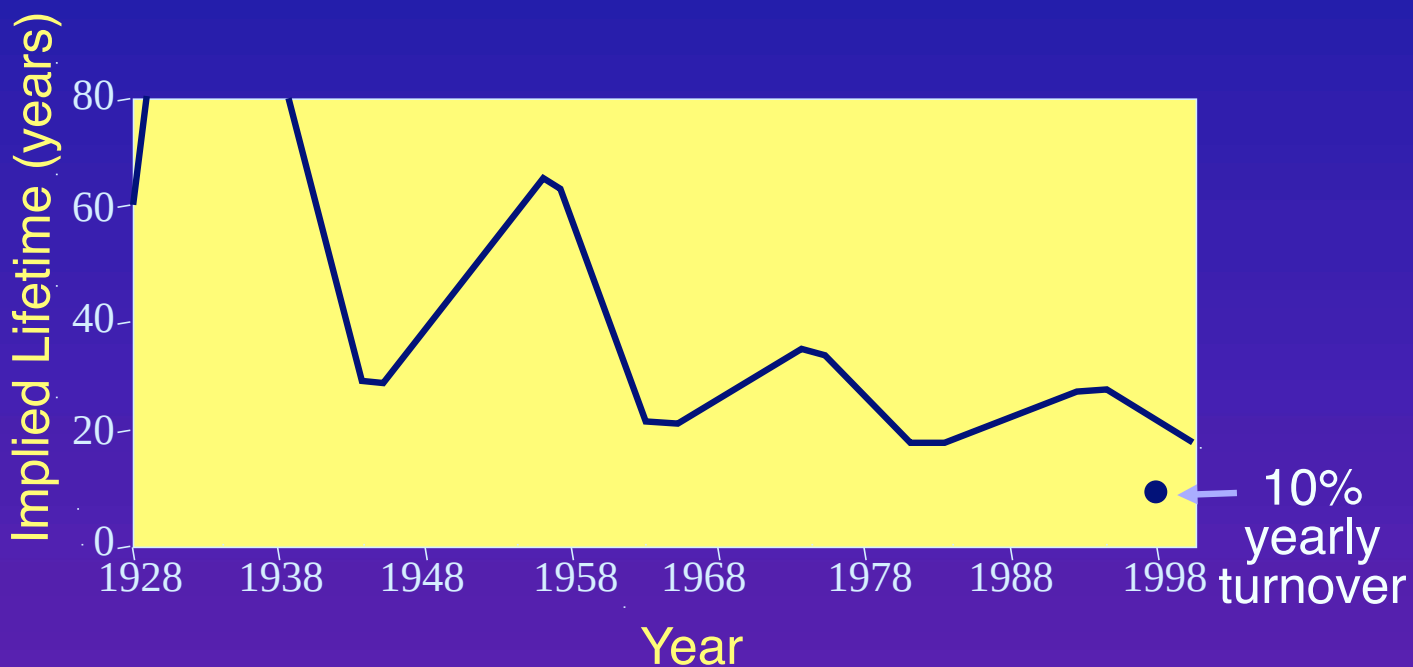
Why aren't we as impressed with human collectives?

Roadmap

- Self-organizing collective systems
- Diversity and development
- Effect of change
- Effect of behavior

Why worry about change?

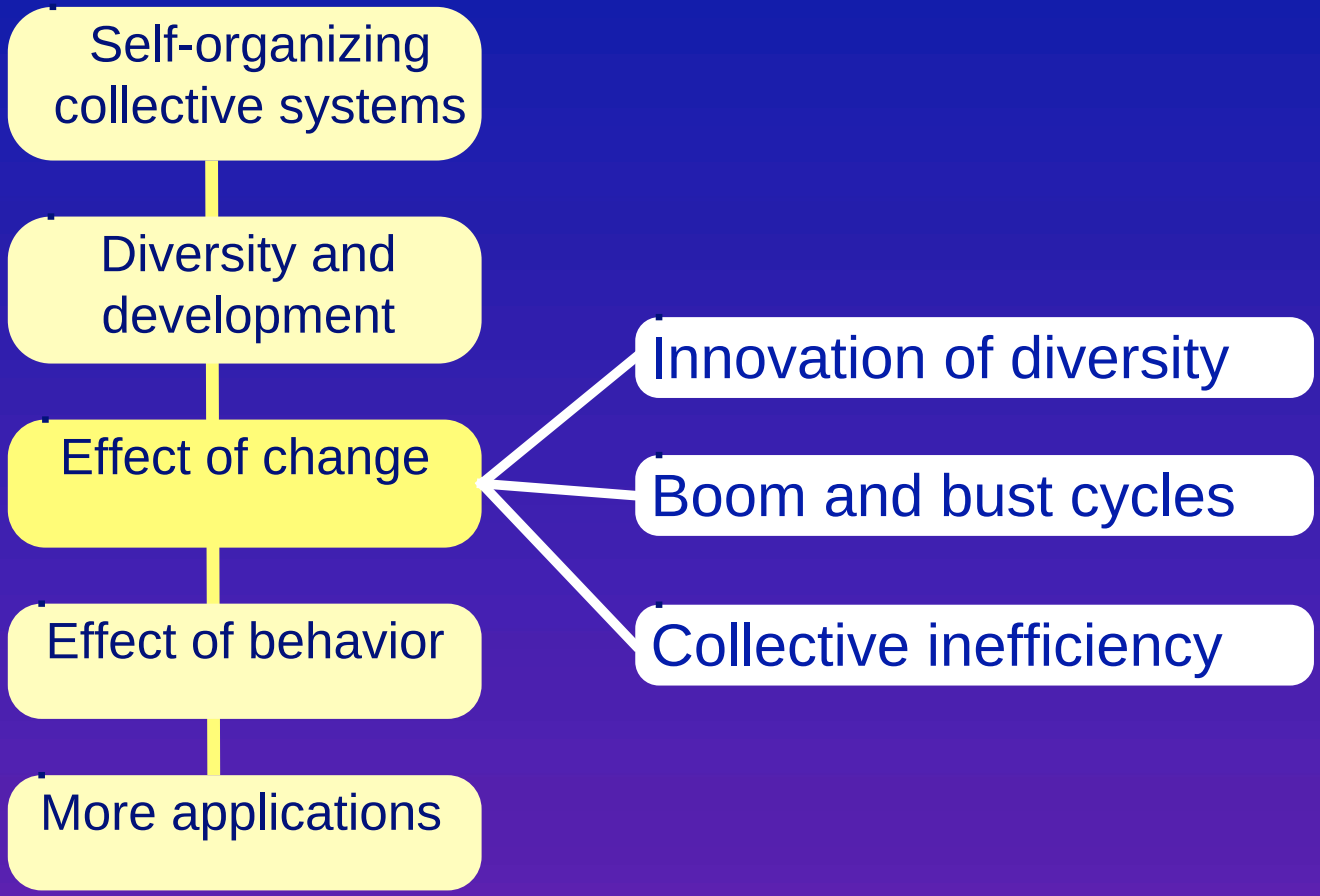
- Average Lifetime of S&P 500 Companies
- From ***Creative Destruction***
- by R. Foster and S. Kaplan



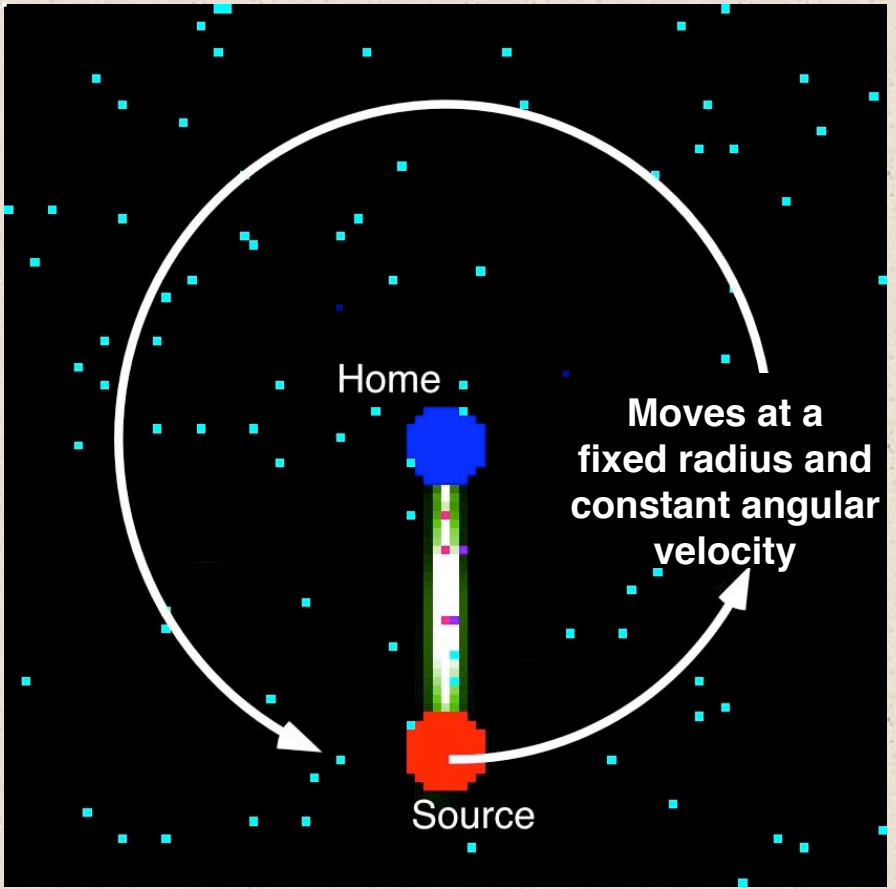
The Impact of Change on Ourselves

- Are you busier this year than last?
- Are you using more information sources than you did last year?
- Do you have more contacts than ever before, but less quality ones?
- Are you tired of hearing “It’s complex”?

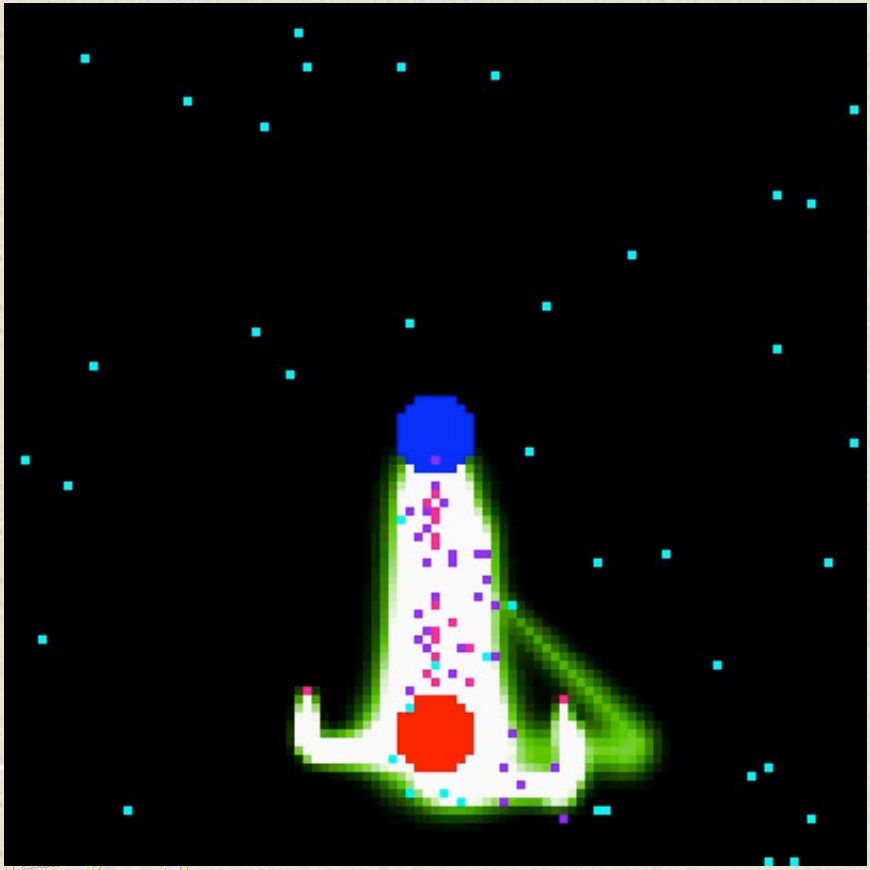
Roadmap


Self-organizing collective systems
Diversity and development
Effect of change
Effect of behavior
More applications
Innovation of diversity
Boom and bust cycles
Collective inefficiency

Collectives in a dynamics environment



Slowly changing environment

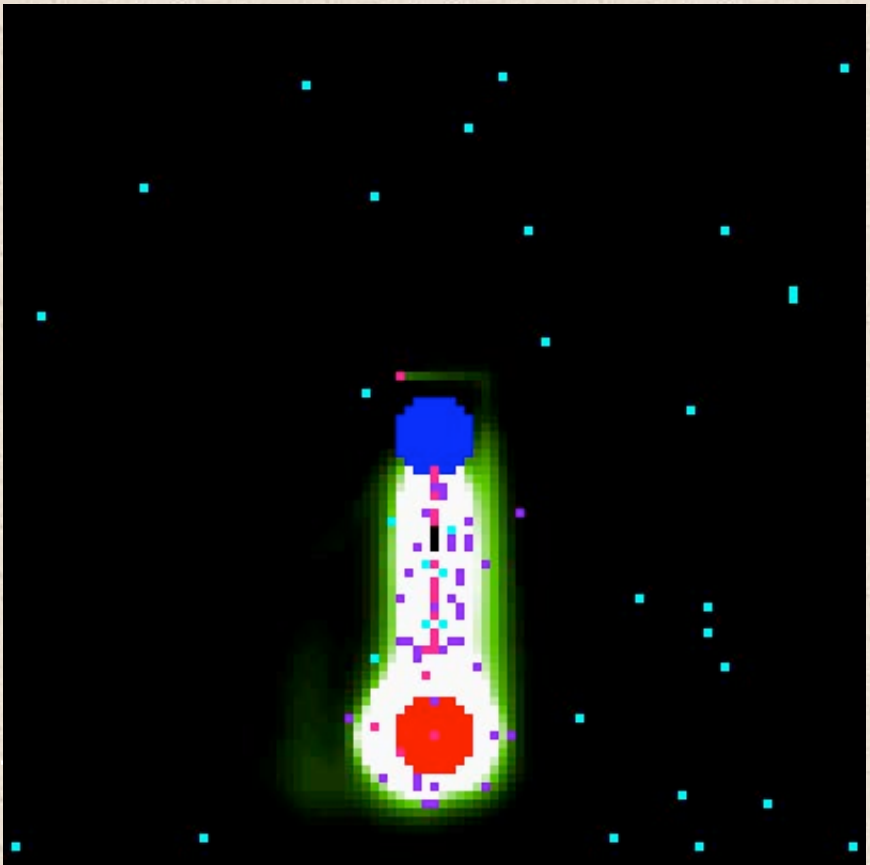


Productivity is only slightly less than an unchanging source

Herd effect allows for quick utilization of new resource location

Innovators become important (again) by sustaining optimal performance of the collective

Faster by 1/3

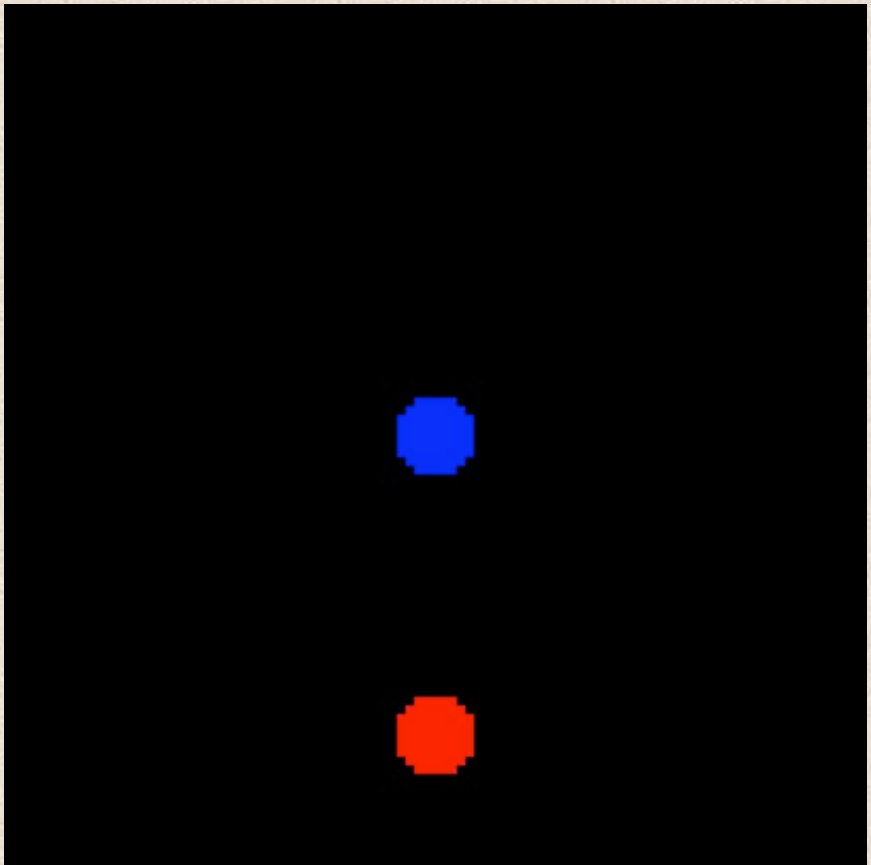


Boom and bust cycle

Instabilities lead to reversion to prior developmental stages.

Equal importance of herd effect and innovators

Rapidly changing in environment

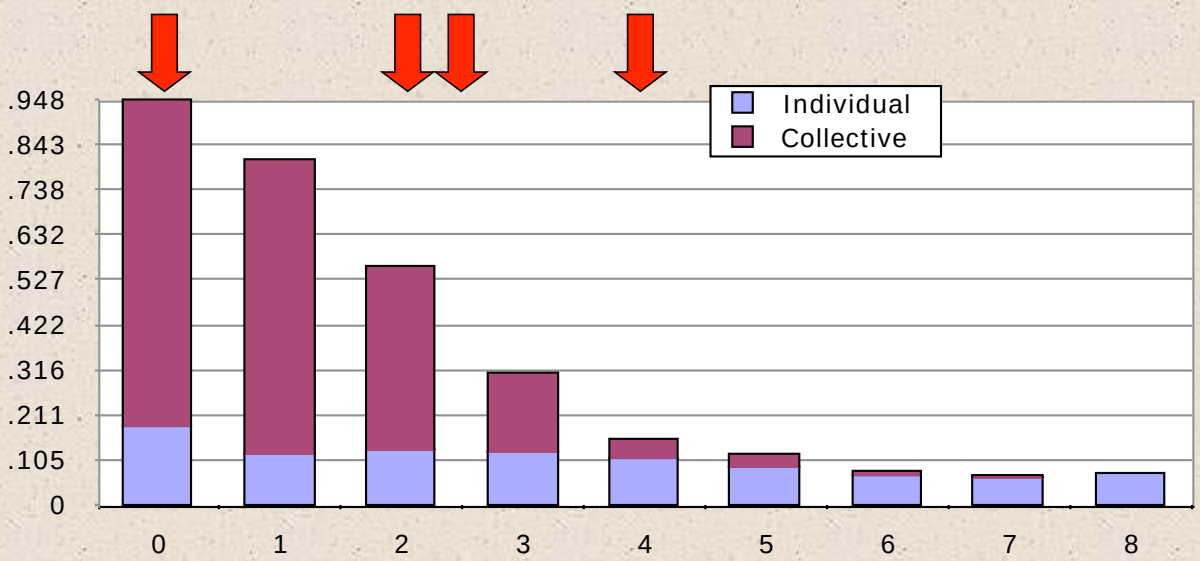


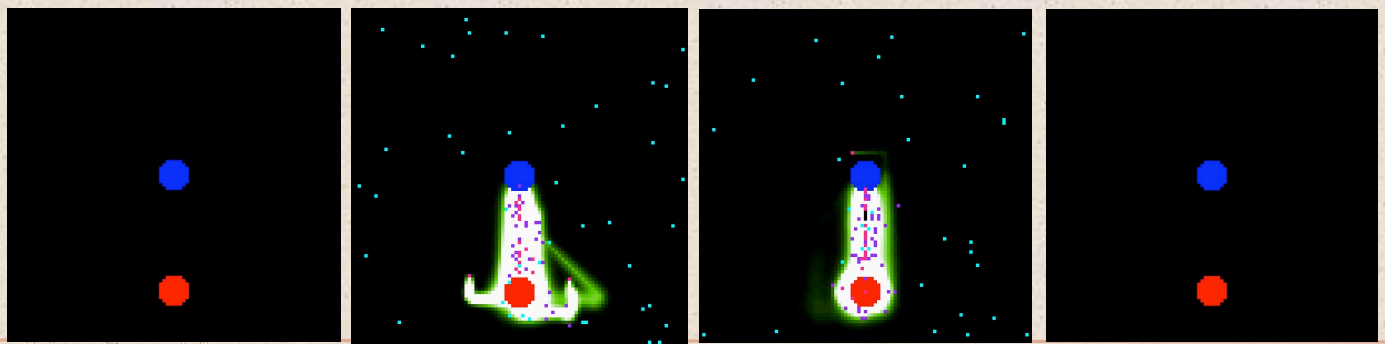
Almost all productivity is from innovators

The highly productive Condensed stage is never realized

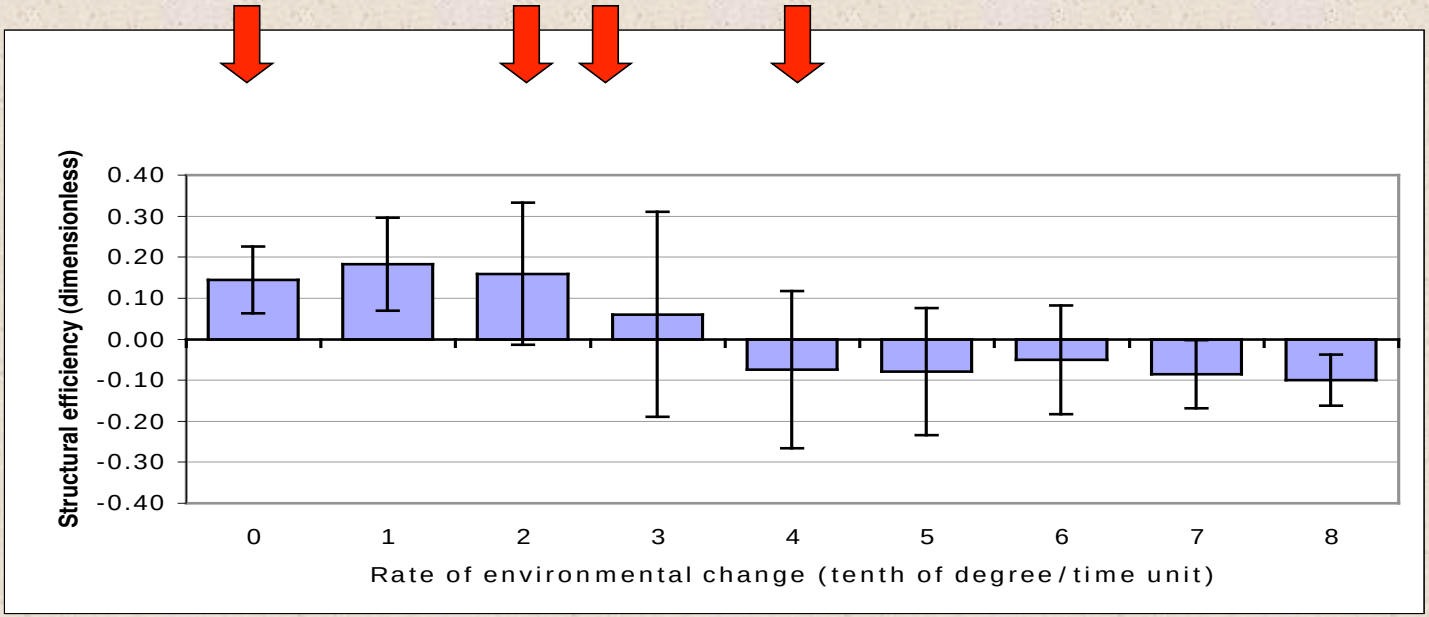
The herd effect can actually degrade the performance by tying up resources

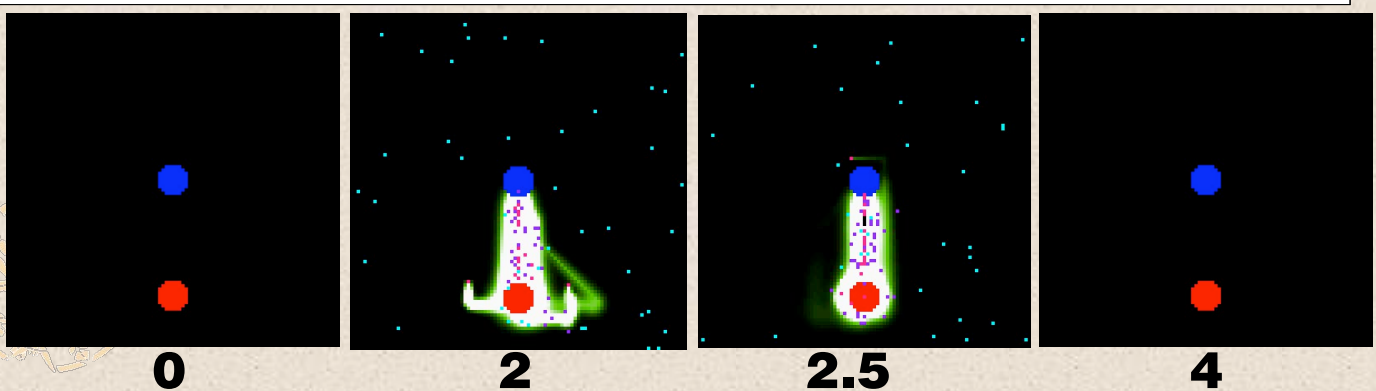
Food Production Rate



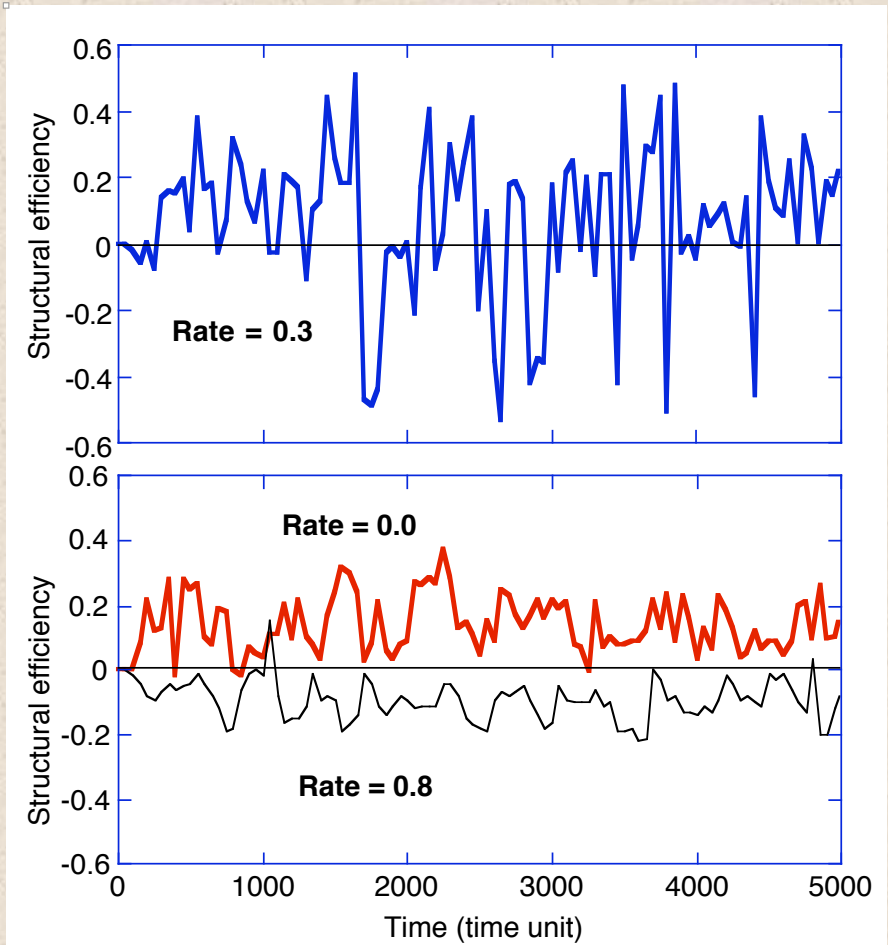


Collective efficacy (structural efficiency)





Structural Efficiency - Boom and Bust



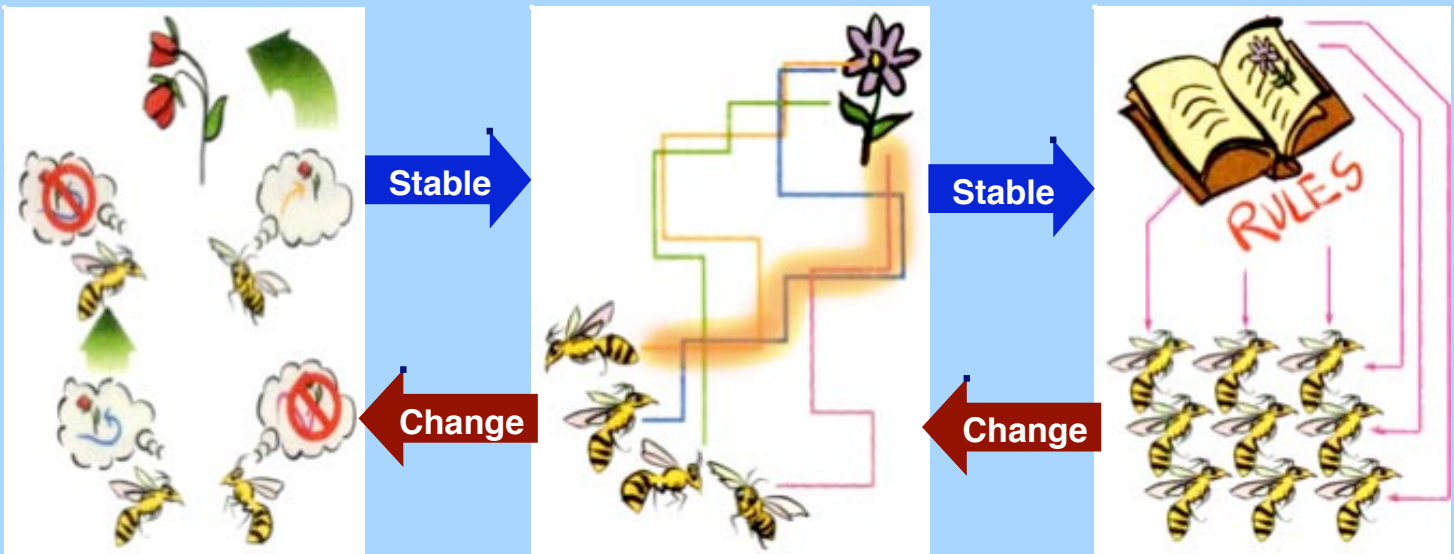
Lower average production -> crash avoidance

Greater minimums and maximum when compared to extreme rates!

Bust is proceeded by increased production

Collective Response to Rates of Change

Formative Co-Operational Condensed



Rate of Change determines the final state

Sustainable strategies in fast changing times

Recognize stages in organizations and groups
- Match actions to stages

Enable, manage and sustain diversity
- Diverse groups = diverse information
- Diverse groups best at recognizing the herd in action
- Diverse groups optimal for filtering and amplifying innovation
- Socialize "world views" and common understanding

Activate self-organizing processes
- Keep strategic plans simple (Eisenhardt)
- Focus on process, not products

Improve your response to herd behavior
- Recognize herding by loss of diversity and reduced social network
- The herd solution will not be robust or optimal

Consider universal ethics vs. local community ethics

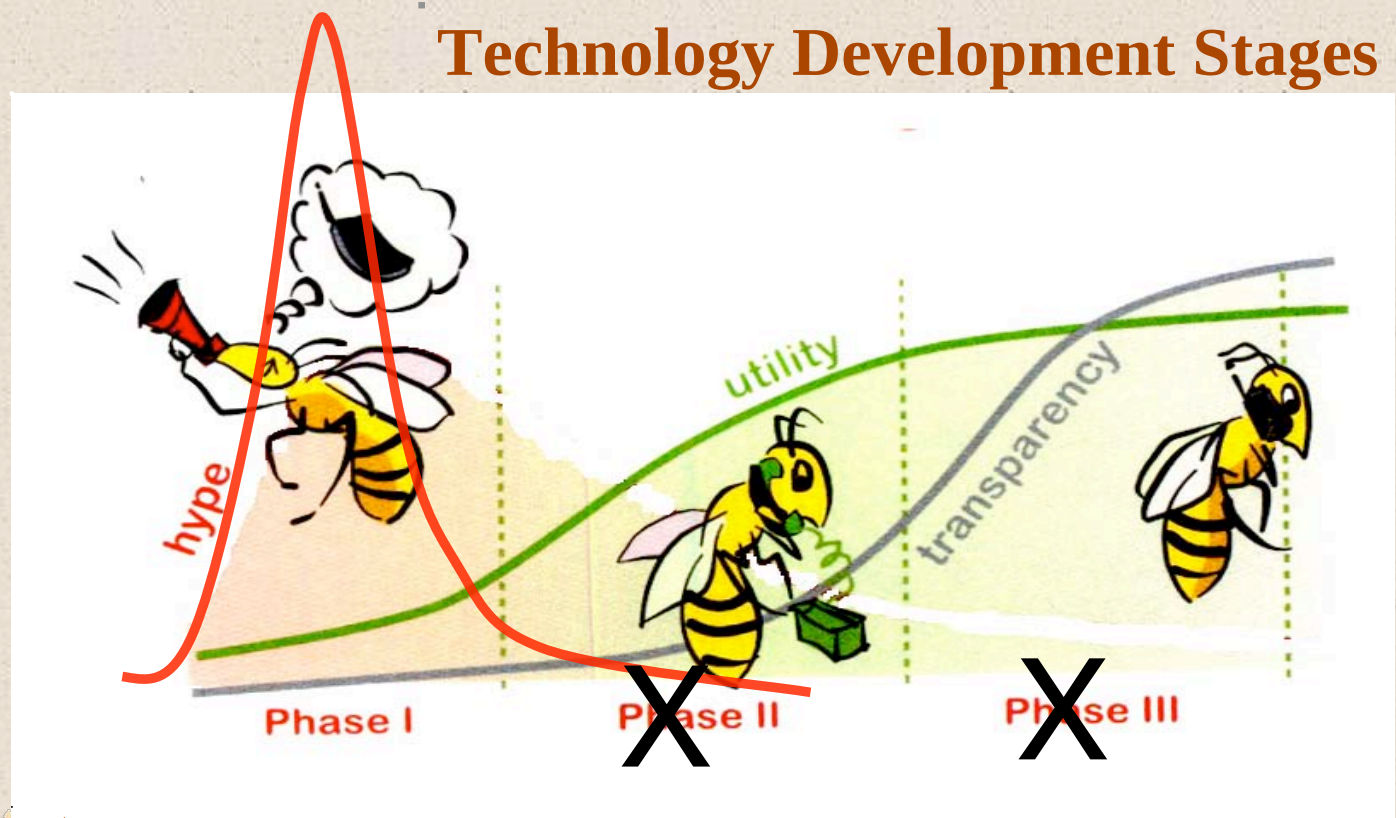
“Typical scientist … he never talked about emotions”

Roadmap

- Self-organizing collective systems
- Diversity and development
- Effect of change
- Effect of behavior
  - Individual behavior complicates everything
  - Individual behavior simplifies dynamics
  - Individual behavior can “lock-in” excursions in collective dynamics

What about individual & collective behavior?

Technology Development Stages



- Collective reinforcement of unsatisfied expectations can lead to a interruption of the developmental cycle

Levels of Social complexity

Social: diverse, decentralized, collective survival and problem solving

Collectively adaptable, Collective memory

Individual reasoning and adaptation, emotions

Self-awareness
Consciousness

Individual preference + Social drives + Options + Rationality = ?

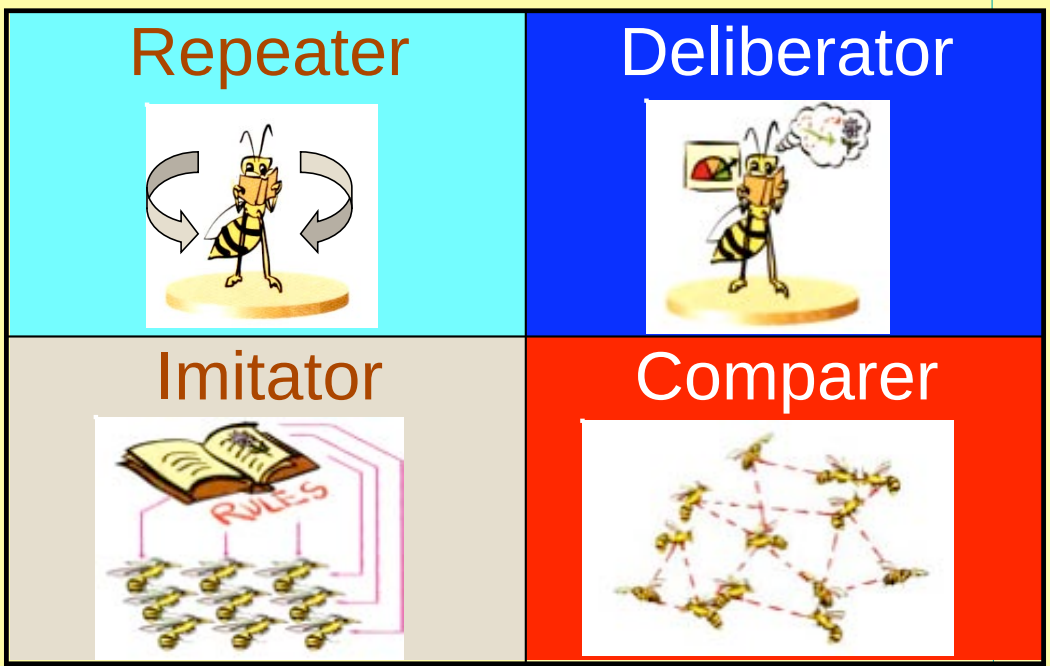
- **Individual optimization of decision**:
  - Theory of reasoned action (*Fishbein & Ajzen*), Theory of planned behavior (Ajzen)
- **Socially aware**:
  - Social comparison theory (*Festinger*), Group comparisons (*Faucheux & Mascovici*)
- **Social imitation**:
  - Social learning theory (*Bandura*), Social impact theory (*Latané*), Theory of normative conduct (*Cialdini, Kalgren & Reno*)
- **Habitual repetition**:
  - Classical conditioning theory (*Pavlov*), Operant conditioning theory (*Skinner*)

Marco Janssen & Wander Jager – Netherlands

Individual Behavior on two axes

Increased Cognition

Increased Social Copying



Causes of Change in Individual Behavior

Historical comparison

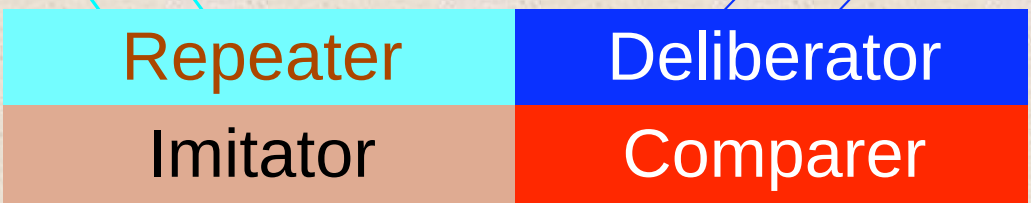
Increased stress	Satisfied	Dissatisfied
Certain	Repeater 	Deliberator 
Uncertain	Imitator 	Comparer 

Highly stable with sustained, but unenabled diversity

Rapid volatility "Formative Stage"

"Dumb" agent

Homo Economicus



Social copying

Social and Rational

Highly stable - decreased diversity "Condensed" stage

Long time volatility - difficult to sustain

Sustainable strategies in fast changing times

Recognize stages
Enable, manage and sustain diversity
Activate self-organizing processes
Improve your response to herd behavior
Consider universal ethics

Recognize behavioral lock-in in clients and partners

Resist social copying under stress

Instead, increase your sources of diverse information

Increased individual "rationality" may lead to destabilization and chaotic performance

Applications

- This is a time of compressed learning - not too different than the Cambrian age.
- How we are categorized? At a cocktail party you are asked: what is your profession?
- "handicap" in dance
- Internet makes almost everyone a researcher - a processor of information.
- The Complexity barrier also applies to discrimination
- Training technical staff (from Lionel LaRoche):
  - Technical people may not be receptive to games and playful activities
  - They will tend to analyze training activities looking for how they work and the reasons they are designed as they are.
  - They may run the activity in their heads (i.e., as a thought experiment) rather than doing it physically as intended by the trainer.
  - Qualitative data will have little probative value to them.
  - They will want to fully understand how quantitative data was collected and conclusions drawn from it.
  - Technical people may not be as versed in "human processes and group dynamics" and so may have more trouble completing tasks relying on those skills

Diversity and Fast Changing times

"Problems cannot be solved at the same level of awareness that created them." *Albert Einstein*

Self-organizing collective systems	More widespread than commonly recognized
Diversity and development	Better understanding of Diversity - when in conflict or synergy
Effect of change	How diversity can help cope with change
Effect of behavior	Behavior and collectives need not be mysterious and unmanageable